REMARKS

Applicants have amended their claims in order to further clarify the definition of various aspects of the present invention. Specifically, Applicants have amended claim 1 to incorporate therein the subject matter of claim 2, and, additionally, to recite that the apparatus also includes a source of an additive gas containing carbon, to be added to an etching gas supplied to the processing chamber. In light of amendments to claim 1, Applicants have cancelled claim 2 without prejudice or disclaimer, and have respectively amended claims 3 and 4 to recite that the additive gas is a carbon monoxide (CO) gas, and to recite that the additive gas is a methane (CH_4) gas diluted with an argon (Ar) gas.

Moreover, Applicants have amended claim 6 to incorporate therein the subject matter of both of claims 7 and 8; and, correspondingly, have cancelled claims 7 and 8 without prejudice or disclaimer.

In addition, Applicants are adding new claims 9-20 to the application. Claims 9 and 11, each dependent on claim 6, respectively recites that the additive gas is a carbon monoxide gas, and recites that the additive gas is a methane gas diluted with an argon gas. Claims 10 and 12, dependent respectively on claims 9 and 11, recite a flow ratio of the etching gas to the additive gas, consistent with flow rates respectively set forth in Figs. 3 and 4 of Applicants' original disclosure. Claims 13 and 15, dependent respectively on claims 3 and 4, respectively recite a flow ratio of the etching gas to the additive gas in connection with the species in claims 3 and 4; and claims 14 and 16, dependent respectively on claims 3 and 4, recite that the apparatus further includes structure to control flow of the etching gas and of the additive gas such that a flow rate of etching gas to the additive gas is 2.5 to 1 or 1 to 3. Claim 17, dependent on claim 1 recites that the semiconductor ring is made of

silicon material; and claim 18, also dependent on claim 1, recites that the semiconductor ring is disposed, and the bias voltage applied thereto, such that silicon-based plasma products generated in a plasma process using the plasma etching apparatus can be deposited stably on the ring. Claims 19 and 20, dependent respectively on claims 6 and 1, recite that silicon-containing components generated during the plasma etching method (during use of the plasma etching apparatus) bond to carbon of at least one of the additive gas and the resin layer and are evacuated from the processing chamber.

In connection with amendments to previously considered claims, and in connection with the newly added claims, note, for example, pages 4-6 of Applicants' original specification, as well as Figs. 3 and 4 and discussions in connection therewith on pages 11-13 of Applicants' specification.

Applicants respectfully submit that all of the claims presented for consideration by the Examiner patentably distinguish over the teachings of the prior art applied by the Examiner in rejecting claims in the Office Action mailed November 30, 2005, that is, the teachings of the U.S. patents to Tsukamoto, No. 5,868,848, to Ohmi, et al, No. 6,719,875, to Shan, et al, No. 6,232,236, to Steger, No. 5,085,727, to Nowak, et al, No. 5,865,896, to Ma, et al, No. 6,554,954, and to Li, et al, No. 6,506,685, and the published United States Patent Applications of Singh, et al, No. US 2004/0231800, and of Hirose, No. US 2004/0211518, under the provisions of 35 USC 102 and 35 USC 103.

It is respectfully submitted that these reference as applied by the Examiner would have neither taught nor would have suggested such a plasma etching apparatus for etching an organic film as in the present claims, having (a) the semiconductor ring disposed on an outer circumference of the substrate to be

processed and having a bias voltage applied thereto, (2) the resin layer formed of a carbon material on an inner wall surface of the processing chamber, and (3) the source of an additive gas containing carbon, to be added to the etching gas supplied to the processing chamber. See claim 1.

Furthermore, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested such a plasma etching method for etching an organic film as in the present claims, including, inter alia, (1) disposing the semiconductor ring on an outer circumference of a substrate to be processed, with a bias voltage applied to the ring, and controlling the bias voltage to control degree of deposition of silicon-based reaction products on the surface of the ring, (2) disposing a resin layer formed of a carbon material on an inner wall surface of the processing chamber, and (3) adding an additive gas containing carbon to the etching gas. See claim 6.

In addition, it is respectfully submitted that the teachings of the applied references do not disclose, nor would have suggested, such plasma etching apparatus and such plasma etching method as in the present claims, having features as discussed previously in connection with claims 1 and 6, and, moreover, wherein the additive gas is a carbon monoxide gas (see claims 3 and 9) or a methane gas diluted with an argon gas (see claims 4 and 11), having respective flow rates as set forth in claims 10, 12 and 13-16, e.g., wherein the apparatus includes structure to control flow rates so as to provide the recited flow ratios (note claims 14 and 16); and/or wherein the semiconductor ring is made of a silicon material (see claim 17); and/or wherein at least a material or size of a susceptor member disposed between the ring and an electrode is adjusted according to an area to be etched on the substrate to be processed (see claim 5); and/or wherein the ring is disposed, and a

bias voltage applied thereto, such that silicon-based plasma products generated in a plasma processing using the plasma etching apparatus can be deposited stably on the ring (see claim 18); and/or wherein during the method, silicon-containing components are generated, and bond to carbon of at least one of the additive gas and resin layer and are evacuated from the processing chamber (note claims 19 and 20).

The present invention relates to a plasma processing apparatus and method, particularly for processing an insulated film material, for a wiring layer, having a low dielectric constant.

In conventional plasma processing, quality of the process is greatly affected by the temperature of the wafer being processed and the inner wall of the reactor, and by the status of reaction products deposited on the inner wall. In addition, if reaction products deposited on the interior of the reactor are exfoliated, they become the source of particulates that may lead to deterioration of properties of devices formed, or degradation of yield. As can be seen in the foregoing, it is important to control the temperature inside the reactor, and to control deposition of reaction products on the inner surface of the reactor, and to promptly evacuate the reactor, in order to maintain stable processing and reduced generation of contaminants. Note the second full paragraph on page 2 of Applicants' specification.

Against this background, Applicants provide apparatus, and processing, wherein such contaminants deposited on inner wall surfaces of the processing chamber can be avoided, and reaction products generated by use of the plasma etching apparatus can be evacuated, such that deposition of reaction products on the inner wall surfaces of the chamber can be avoided; and deposition of contaminants on the substrate being processed (e.g., a semiconductor wafer) can be

avoided, thereby avoiding problems arising with conventional techniques and discussed previously.

Specifically, Applicants have found that by disposing a ring formed of a semiconductor (e.g., formed of silicon material) on the outer circumference of the substrate to be processed, and applying a bias voltage thereto, reaction between the ring surface and silicon-based reaction products caused by the plasma process can be controlled appropriately, and such reaction products generated by the plasma can be deposited stably on the ring, by which amount of contaminants attached to the substrate being processed can be suppressed. Moreover, by applying a bias voltage to the ring, the reaction can be controlled, and rate of deposition of the reaction products can be suppressed, whereby reaction products can be maintained in the gas and evacuation thereof can be increased, effectively reducing amount of contaminants being attached to the substrate being processed. Note the paragraph bridging pages 4 and 5 of Applicants' specification.

In addition, by use of the resin layer formed of a carbon material, which has a high binding energy with silicon generated by the etching, the carbon and silicon easily react and are evacuated from the chamber. Similarly, silicon components bond easily with carbon of the gas containing carbon components added to the etching gas, and are evacuated from the chamber. Accordingly, the silicon components can be removed from the processing chamber, whereby amount of contaminants is reduced. Note the two full paragraphs on page 5 of Applicants' specification. In addition, by providing a carbon material on an inner wall surface of the processing chamber, even when carbon is deposited on the resin surface, since it has a high binding energy, the deposition is stable, avoiding contaminants on the substrate being processed.

Accordingly, through all of the features of the present invention, amount of contaminants attached to the processed substrate can be suppressed, without deteriorating etching properties and the processed profile of the etched structure.

Note, for example, Figs. 5 and 6 of Applicants' original disclosure, particularly together with the description in connection therewith on pages 14 and 15 of Applicants' specification. It is respectfully submitted that the evidence of unexpectedly better results achieved according to the present invention, having the features as discussed previously, support a conclusion of unobviousness of the presently claimed subject matter. See In re DeBlauwe, 222 USPQ 191 (CAFC 1984).

Tsukamoto discloses a plasma processing apparatus for processing an object to be processed such as a semiconductor wafer by use of a plasma, wherein the apparatus includes a lower electrode in a processing chamber, the substrate to be processed being held on the lower electrode, and with a measuring electrode connected to the lower electrode, being provided around the substrate to be processed, so as to be exposed in the plasma. See column 1, lines 54-60. Note, also column 2, lines 34-36 and 55-59, disclosing that since the measuring electrode is provided around the object being processed, it is possible to measure a V_{DC} around the object being processed. See also column 2, lines 44-46, disclosing examples of materials for use in the measuring electrode, including metals such as aluminum and tungsten, semiconductors such a silicon, and ceramics such as SiC. See also column 4, lines 5-20. Note also the description in column 4, lines 35-40, disclosing a gas inlet and a gas supply pipe connected to the gas inlet, with the gas supply pipe supplying a predetermined etching reaction gas such as CF_4 gas connected via a mass-flow controller.

It is emphasized that Tsukamoto, et al, discloses a measuring electrode, and discloses a carbon-containing etching gas. It is respectfully submitted that this patent does not disclose, nor would have suggested, the additive gas containing carbon, in addition to the etching gas; and would have neither taught nor would have suggested the semiconductor ring and bias voltage applied thereto, much less the further disclosure of the semiconductor ring as in, e.g., claims 17 and 18, and advantages thereof according to the present invention. Moreover, it is respectfully submitted that Tsukamoto does not disclose, nor would have suggested, the resin layer formed of carbon as in the present claims, and advantages thereof.

It is respectfully submitted that the additional teachings of Hirose, Steger or Singh, et al, would not have rectified the deficiencies of Tsukamoto, such that the presently claimed invention as a whole would have been obvious to one of ordinary skill in the art.

Singh, et al, discloses an apparatus and method of cleaning a processing chamber to remove previously deposited chamber residues which have accumulated on interior surfaces of the apparatus, wherein a removable coating is provided to the inner surfaces of the processing chamber. Note paragraphs [0003] and [0011] on pages 1 and 2 of this publication. Note also paragraph [0012] on page 2, disclosing the method for removing deposits in between process operations of a semiconductor processing chamber, which is initiated with depositing a carbon and fluorine containing polymer layer over an inner surface of a semiconductor processing chamber when the chamber is empty; and after introducing a wafer into the chamber and performing a processing operation thereon, which deposits a residue on the fluorine containing polymer layer, removing the wafer and next performing an oxygen-based cleaning operation to liberate fluorine from the fluorine containing

polymer layer to remove a silicon-based residue. Note also paragraph [0027] on page 2 of this publication.

Hirose discloses a plasma processing apparatus capable of suppressing a damage due to sputtering to a wall surface of a processing chamber during plasma processing, the apparatus being described most generally in paragraph [0015] on page 1 of this publication. Note also paragraph [0013] on page 1 of this publication, describing "Related Art", and indicating that, conventionally, counter measures have been taken to suppress damages to the wall surface, including use of a resin coating applied to the wall surface to prevent wear to the wall surface.

Steger discloses a plasma etching chamber of a plasma etching apparatus, provided with a protective conductive coating formed on the inner metal surfaces of the chamber, the protective layer preventing or inhibiting chemical attack of the metal surfaces by the reactant gases employed in the plasma etching process. See column 1, lines 10-14, and column 2, lines 51-59. See also column 3, lines 30-34 and 46-55, disclosing, inter alia, use of a protective carbon coating on the metal chamber walls; and the paragraph bridging columns 3 and 4, describing various materials that can be used as the conductive coating material applied to the inner metal surfaces of the etching chamber.

Even assuming, arguendo that the teachings of Steger, Hirose, or Singh, et al, were properly combinable with the teachings of Tsukamoto, it is respectfully submitted that such combined teachings would have neither disclosed nor would have suggested the combination of features as in all of the present claims (that is, all of the combination of (1) the semiconductor ring, with bias voltage applied thereto, (2) the resin layer formed of a carbon material, and (3) the additive gas containing carbon, added to the etching gas supplied to the processing chamber), and

advantages thereof, in particular, the unexpectedly better results achieved thereby in avoiding contaminants in the processing chamber; and/or other features of the present invention as discussed previously, and advantages thereof.

The contention by the Examiner in, for example, the last paragraph on page 2 of the Office Action mailed on November 30, 2005, that "an apparatus is being claimed as the instant invention", is noted. The Examiner's attention is respectfully directed to, e.g., claim 6 and claims dependent thereon, reciting a plasma etching method for etching an organic film. Clearly, comments by the Examiner with respect to "an apparatus...being claimed as the instant invention" is incorrect with respect to claim 6 and claims dependent thereon.

Moreover, note that the present apparatus claims recite a source of an additive gas containing carbon, to be added to an etching gas supplied to the processing chamber. It is respectfully submitted that this source constitutes an apparatus recitation, that must be given weight in determining patentability of the presently claimed apparatus.

The additional contention by the Examiner that Tsukamoto discloses a semiconductor ring disposed on an outer circumference of the substrate to be processed, and having a bias voltage applied to the ring, is noted. As can be appreciated, in the present claims the apparatus and method are defined as including a combination of features, which would have neither been disclosed nor would have been suggested by the teachings of Tsukamoto, with or without the teachings of the references applied therewith, as discussed previously.

Moreover, attention is respectfully directed to e.g., claim 18, further defining the semiconductor ring. It is respectfully submitted that Tsukamoto would have

neither taught nor would have suggested this aspect of the present invention, and advantages thereof.

Ohmi, et al, discloses a plasma processing apparatus provided with two electrodes of parallel plate type and a magnetic field applying means for applying a magnetic field, wherein an auxiliary electrode is provided around the periphery of one of the two electrodes, a space where a plasma can be excited is provided at the opposite side of the auxiliary electrode to the face facing the other electrode, and a means for applying a high-frequency power to the auxiliary electrode is provided. See column 2, lines 13-24. Note also column 2, lines 25-29; and column 4, lines 55 and 56. Note also auxiliary electrode 107 shown in, e.g., Fig. 1.

It is respectfully submitted that Ohmi, et al, would have neither taught nor would have suggested the combination of features as in the present claims, including the electrode ring and bias applied thereto, together with the resin layer and source of additive gas (or with respect to the method claims, adding the additive gas), and advantages thereof as discussed previously.

Ma, et al, discloses an electrically conductive collar or ring surrounding a workpiece in a plasma chamber used for semiconductor fabrication, capable of reducing or eliminating electrical arcing from exposed metal at the perimeter of the workpiece. The plasma chamber includes a cathode electrode adjacent the workpiece, and a dielectric shield encircling the perimeter of the workpiece, with an electrically conductive collar also encircling the perimeter of the workpiece and overlying the dielectric. See column 1, lines 55-61. Note also column 1, lines 64-67; the paragraph bridging columns 4 and 5; column 5, lines 13-16; the paragraph bridging columns 6 and 7; and column 7, lines 27-39.

Li, et al., discloses an apparatus and method for etching through a silicon-dioxide containing material during IC fabrication, to create etched features, the apparatus being described most generally in column 2, lines 23-37. Note also column 4, lines 8-10, 32 and 48-51; column 5, lines 10-14; and column 6, lines 8-14, of this patent.

Even assuming, arguendo, that the teachings of Ma, et al, and of Li, et al, were properly combinable with the teachings of Ohmi, et al, such combined teachings would have neither disclosed nor would have suggested the combination of features as in the present claims, providing advantages as discussed previously.

Noting the rejection of claims set forth in the first full paragraph on page 5 of the Office Action mailed November 30, 2005, even taking into account the teachings of Hirose, Steger or Singh, et al, together with the teachings of Ohmi, et al, with Ma, et al, or Li, et al, such combined teachings would have neither disclosed nor would have suggested the combination of features recited in the present claims, and advantages thereof.

With respect to the rejection of claims set forth in the first paragraph on page 6 of the Office Action mailed November 30, 2005, Ohmi, et al, and Tsukamoto have previously been discussed.

Nowak, et al, discloses a high-density plasma CVD reactor having conductive and capacitive coupling modes which can be selected individually or in combination for chamber cleaning operations, the apparatus being described most generally in column 3, lines 18-34.

Even assuming, arguendo that the teachings of Nowak, et al, or of Tsukamoto were properly combinable with the teachings of Ohmi, et al, such combined teachings would have neither disclosed nor would have suggested the combination

of features as in the present claims and as discussed previously, and advantages thereof.

The contention by the Examiner that Nowak, et al, discloses an electrode 24 composed of a semiconductor, is noted. Such electrode is a ceiling electrode, connectable to either an RF source or ground. In any event, such ceiling electrode, even in combination with teachings of Ohmi, et al, as applied by the Examiner, would have neither disclosed nor would have suggested the combination of features as in the present claims, and advantages thereof.

In connection with the rejection of claims in the first full paragraph on page 7 of the Office Action mailed November 30, 2005, it is respectfully submitted that the combination of teachings of these references, including one of Hirose, Steger and Singh, et al, would have neither disclosed nor would have suggested the combination of features as in the present claims, and advantages thereof. In this regard, Hirose, Steger and Singh, et al, have been previously discussed. The addition of teachings of these references, in combination with the teachings of Ohmi et al, and either Nowak, et al, or Tsukamoto, would have neither taught nor would have suggested the combination of semiconductor ring with bias voltage applied thereto, the resin layer of a carbon material and the source of additive gas (in connection with the method, adding the additive gas), and advantages thereof.

In connection with the rejection set forth in the first paragraph of page 8 of the Office Action mailed November 20, 2005, Shan, et al, discloses an apparatus and method for controlling plasma uniformity in a semiconductor wafer processing system, the apparatus including a wafer support, a conductive process kit surrounding the wafer support and an RF supply coupled to the process kit. The process kit or collar is biased by an RF signal having a frequency that can be the

same as a cathode drive signal or a different frequency. See column 2, lines 46-50; note also column 2, lines 50-60.

Ma, et al and Li, et al, have been previously discussed.

Even assuming, arguendo, that the teachings of Shan, et al were properly combinable with the teachings of Ma, et al or Li, et al, such combined teachings would have neither disclosed nor would have suggested the combination of features as in the present claims, and discussed previously.

Even adding the teachings of any one of Hirose, Steger or Singh, et al, with the teachings of Shan, et al and Ma, et al or Li, et al, such combined teachings would have neither disclosed nor would have suggested the combination of features as in the present claims.

Attention is also respectfully directed to the combination of teachings of Shan, et al and either Nowak, et al or Tsukamoto, alone or further together with the teachings of Hirose, Steger or Singh, et al, as discussed by the Examiner on pages 10 and 11 of the Office Action mailed November 30, 2005. Even combining teachings of references as applied by the Examiner on pages 10 and 11 of the Office Action mailed November 30, 2005, such combined teachings would have neither disclosed nor would have suggested the combination of features as in the present claims, and unexpectedly advantageous results achieved thereby.

Throughout the claim rejections, and as mentioned previously, the Examiner contends that "an apparatus is being claimed as the instant invention". It is respectfully submitted that such contention is clearly in error with respect to, for example, claim 6 and claims dependent thereon, which are directed to a method. Properly construing the method claims, clearly the Examiner must give weight to processing, in determining patentability.

Furthermore, with respect to the apparatus claims, note that these claims recite a source of an additive gas containing carbon, to be added to an etching gas supplied to the processing chamber. It is respectfully submitted that the Examiner must give weight to the apparatus as claimed, including such source.

In addition, the Examiner's attention is respectfully directed to, e.g., claims 10 and 12-16. Such claims define a flow ratio, and structure to control flow so as to provide such flow ratio. As is clear from Applicants' disclosure, and as seen in Embodiments 2 and 3 on pages 11-13 of Applicants' specification, such flow ratios provide further advantages. For the additional reasons with respect to the features in claims 10 and 12-16, and additional advantages achieved thereby, it is respectfully submitted that the teachings of references as applied by the Examiner would have neither disclosed nor would have suggested such aspects of the present invention.

In view of the foregoing comments and amendments, reconsideration and allowance of all claims presently in the application are respectfully requested.

Applicants request any shortage in fees due in connection with the filing of this paper be charged to the Deposit Account of Antonelli, Terry, Stout & Kraus, LLP, Deposit Account No. 01-2135 (case 6348.43545X00), and credit any excess payment of fees to such Deposit Account.

Respectfully submitted,

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